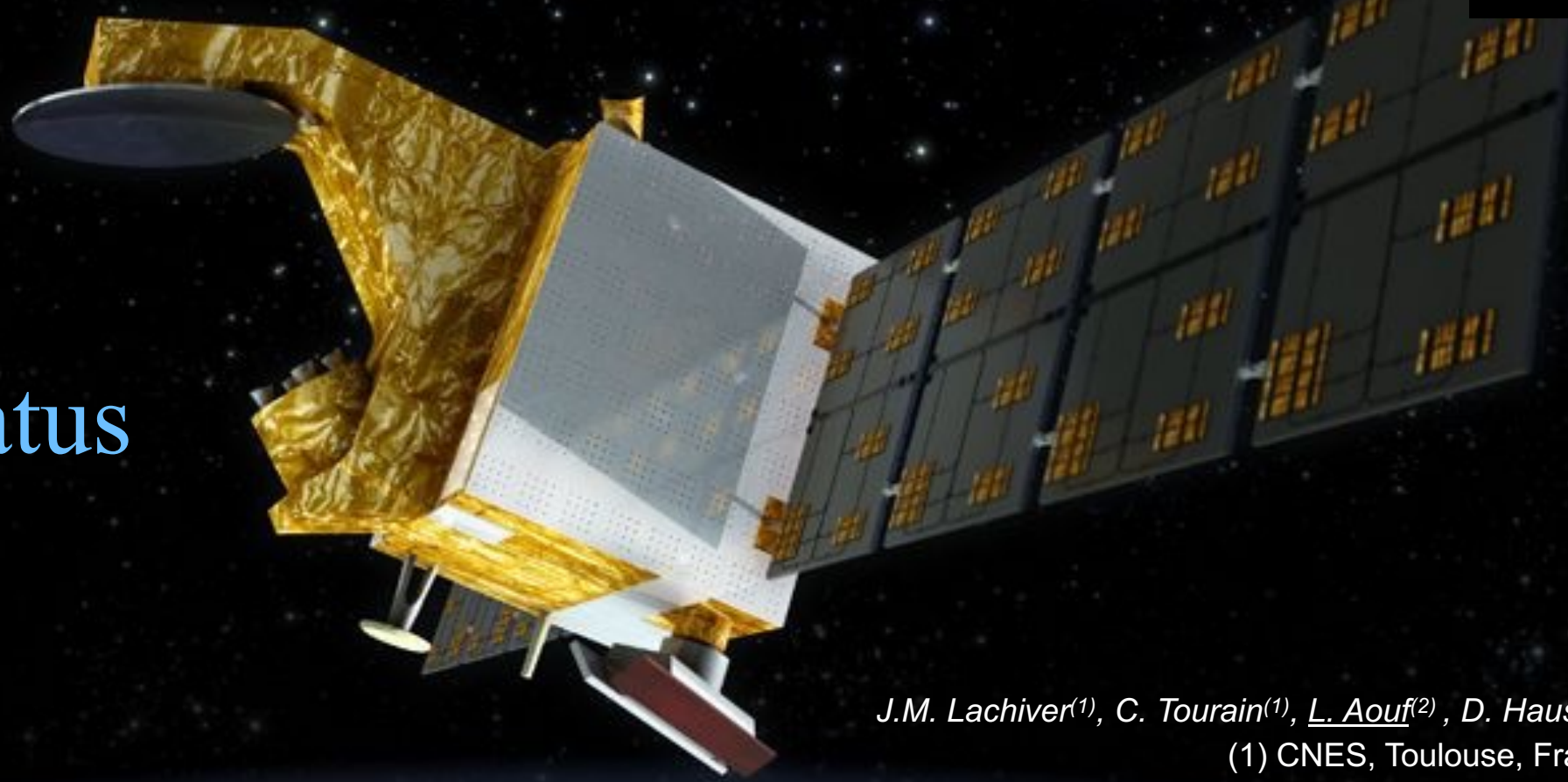


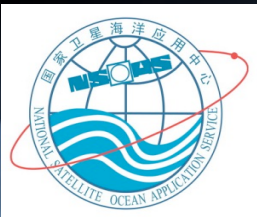


# CFOSAT: China-France Oceanography SATellite



## Mission Status

*J.M. Lachiver<sup>(1)</sup>, C. Tourain<sup>(1)</sup>, L. Aouf<sup>(2)</sup>, D. Hauser<sup>(3)</sup>*  
(1) CNES, Toulouse, France  
(2) Météo-France, Toulouse, France  
(3) LATMOS, CNRS, UVSQ, UPMC, Guyancourt, France



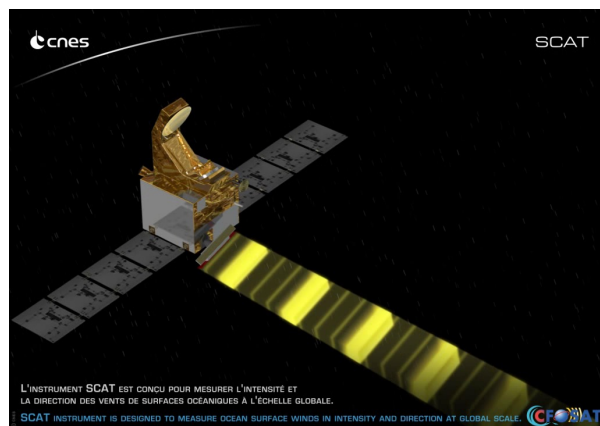
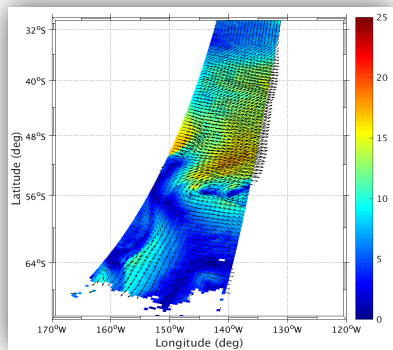
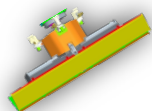
**Main Objective: Measure at the global scale ocean surface wind and waves spectral properties**



**SCAT**

**Wind scatterometer**

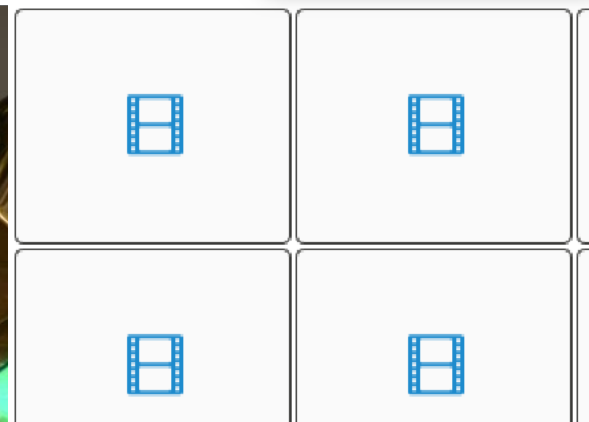
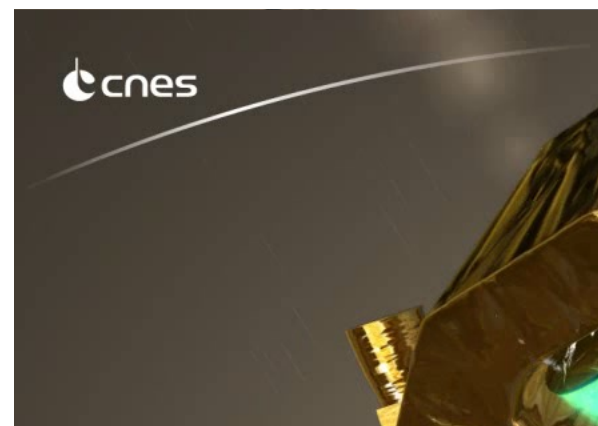
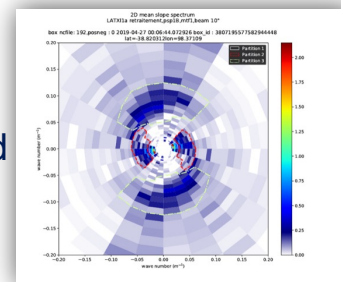
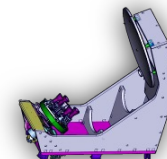
- ❖ Fan beam concept
  - Large swath
  - Rotating antenna: 3 rpm
- ❖ Incidences between 26° and ~50°
- ❖ Provides
  - $\sigma_0$
  - Ocean wind vector



**SWIM**

**Wave scatterometer**

- ❖ Ku band real aperture radar,
- ❖ Sequential illumination with 6 incidences: 0°, 2°, 4°, 6°, 8°, 10°
- ❖ Rotating antenna (all azimuth direction acquisition): 5,6 rpm
- ❖ Provides:
  - Directional wave spectra
  - Significant wave height and wind speed
  - mean profiles, 0° to 10°



2018/10/29: Successful launch

Sept. 2019: 1<sup>st</sup> International Science Team in Nanjing (China)

Feb. 2020: **Data release to users**

- ❖ Aviso+
- ❖ NSOAS/OSDDS

June 2020: **SWIM-NRT for operational applications**

March 2021: 2<sup>nd</sup> International Science Team, e-meeting

Sept. 2022: 3<sup>rd</sup> International Science Team in Saint-Malo (France)

To come: Nov. 2023: 4<sup>th</sup> International Science Team in Nanjing (China)



**Five years in orbit**

**Two years beyond the nominal period**

## Platform

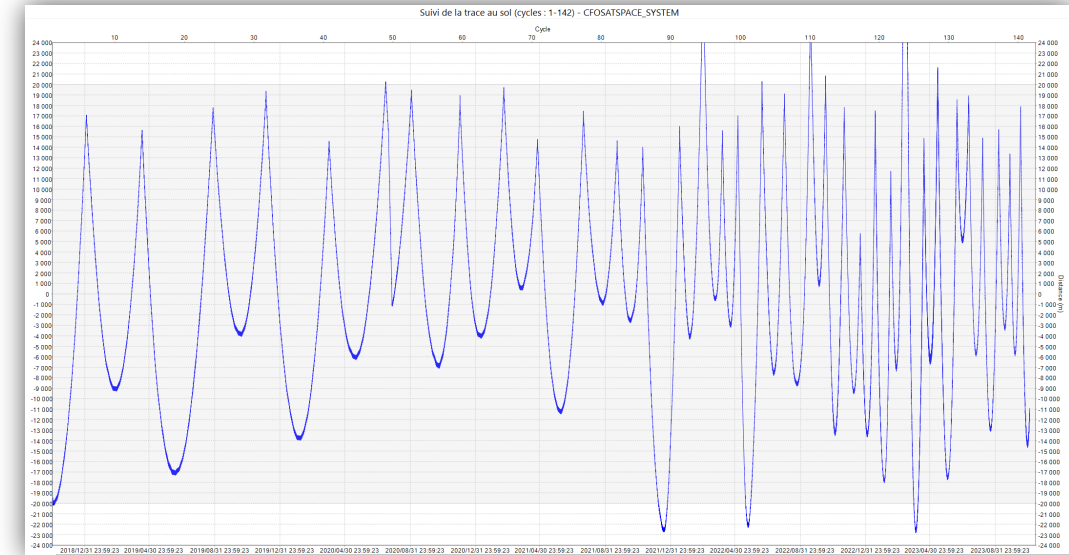
- ❖ CFOSAT bus: **Ok**
- ❖ More frequent station keeping manoeuvre during the last year due to solar activity

## SCAT

- ❖ After the first signs of problem in antenna rotation during Summer 2022, this rotation definitively stopped in December 2022 despite all the efforts made by the Chinese Team
- ❖ The instrument itself continues working and acquiring Telemetry
- ❖ NSOAS Team works on adapting the ground processing in order to get the best information possible from the acquisitions

## SWIM

- ❖ SWIM instrument is: **Ok**



# CaVal instruments performances status

Requirement	Value	Compliance
SCAT Sigma0	± 1.0 dB for Wind Speed [4-6 m/s] ± 0.5 dB for Wind Speed [6-24 m/s]	✓ Up to August 2022
SCAT Ocean Wind Vector	Wind speed: 2 m/s or 10% (the largest) for Wind speed [4-24 m/s] Wind direction: ± 20°	✓ Consistent with models and buoys Up to August 2022
SWIM Nadir	SWH: error < 10% of SWH or 50 cm max Wind Speed: error < 2 m/s	✓
SWIM Sigma0 profiles	Sigma0: restitution better than 1 dB inter-beams bias: error < 0.2 dB	✓
SWIM Wavelength	Wavelength identification range: 70- 500 m Wavelength restitution error: 10%	✓ (50 – 500) ✓ Consistent with models and buoys
SWIM Direction	Restitution error < 15°	Globally compliant with outliers to be analyzed
SWIM Spectral Peak Power	error < 15% (for SWH > 2 m)	✓

## Information about CaVal status available on Aviso+ website (cyclic validation reports)

❖ <https://www.aviso.altimetry.fr/en/missions/current-missions/cfosat/product-qualification.html>

## Earth Terminals

- ❖ Chinese S-Band and X-band stations: **Ok**
- ❖ French X-Band (Kiruna, Inuvik): **Ok**

## Control Center

- ❖ Chinese CLTC: **Ok**

## Mission and processing Centers

- ❖ NSOAS CFMC (Beijing): **Ok**
- ❖ CNES CWWIC NRT processing (Toulouse): **Ok**
- ❖ Ifremer IWWOC DT processing (Brest): **In operation since beginning of 2021**



## CFOSAT Data availability

- ❖ Requirement:
  - The availability of the Satellite for generating Observation data (Measurement and Calibration) shall be greater than 95 %
- ❖ From the beginning of life (2018/10/29) till now (2023/10/29): 1825 days
  - House Keeping manoeuvres (including collision avoidance): 10 days
  - On-board X-band interruption: 5 days
  - SWIM anomaly (2021/01/06): 5 days
  - SCAT switch to redundant (end of December 2019) + switch off: 11 days
  - SCAT antenna stop rotating (2022/12/01): **permanent stop**

**Global CFOSAT Products availability performance:**

**SCAT: 96% before antenna stop**

**SWIM: 98.9%**

## CFOSAT Near Real Time production and distribution

- ❖ Requirement:
  - NRT data shall be made available at meteorological or oceanographic operational centers within 3 hours from acquisition time, with an availability of 75 %
  
- ❖ From the beginning of life (2018/10/29) till now (2023/10/29): 1825 days
  
- ❖ SWIM
  - 93.2 % of SWIM NRT products under 3 hours
  
- ❖ SCAT
  - 96,7 % of SCAT NRT products under 3 hours before antenna stop

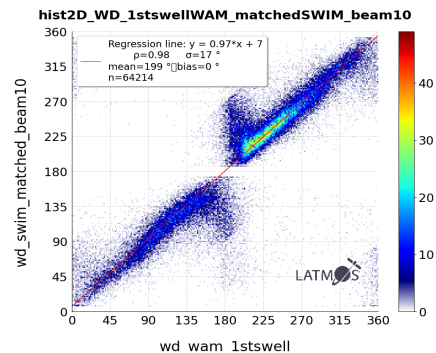


## Main evolutions in the latest product issues

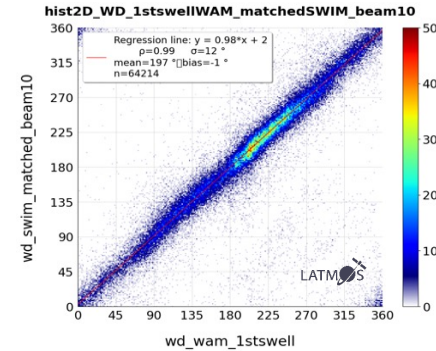
- ❖ 6.0 (2022/06/27)
  - Microcuts detection algorithm improvement
  - Signal variability parameter propagation
  - Sigma0 profiles filtering improvement
- ❖ 2<sup>nd</sup> full reprocessing campaign (OP06 version) available since spring 2023
- ❖ 6.1 (2023/01/17)
  - Modification of the apodisation window centering
- ❖ Product evolutions history given on Aviso+ website:
  - <https://www.aviso.altimetry.fr/en/missions/current-missions/cfosat/product-evolutions.html>

Work on-going for improving products... 7.0 in 2024

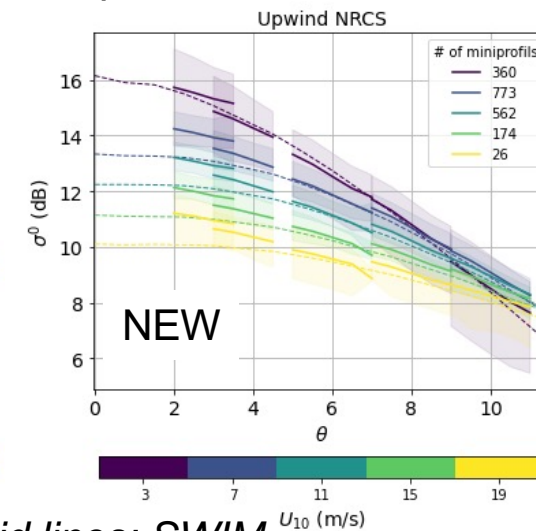
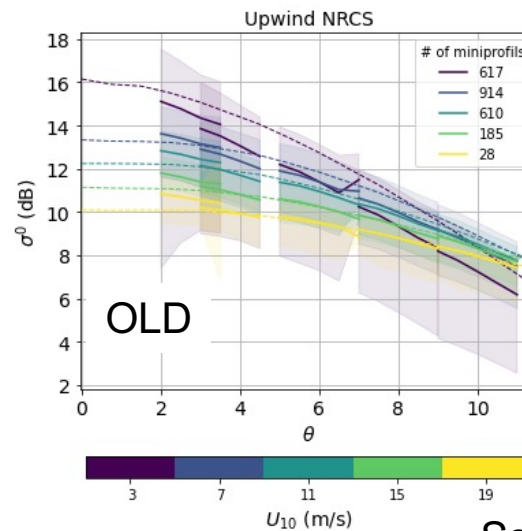
Wave direction from SWIM wave spectra vs WAM model, beam 10°  
5.1 product issue



5.2 product issue



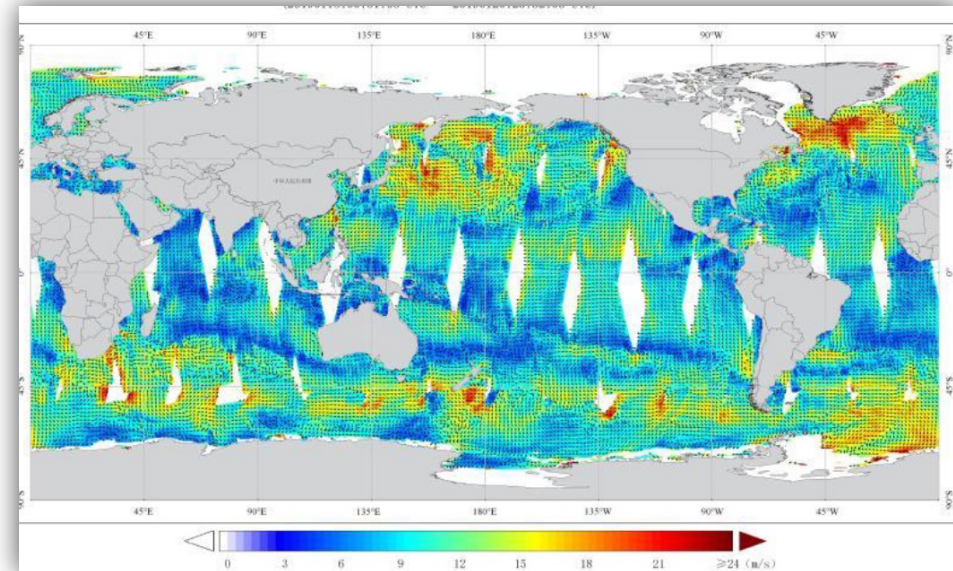
Improvement on mean profiles of  $\sigma_0(\theta)$  (upwind, 13 days)  
for different wind speed classes



Solid lines: SWIM  
Dotted lines: GPM

## Main evolutions in the latest product issues

- ❖ Waiting for processing able to exploit measurements with fixed antenna
- ❖ Full reprocessing of SCAT instrument : campaign already
- ❖ started and wind products will be provided by the end of
- ❖ 2023-early 2024...

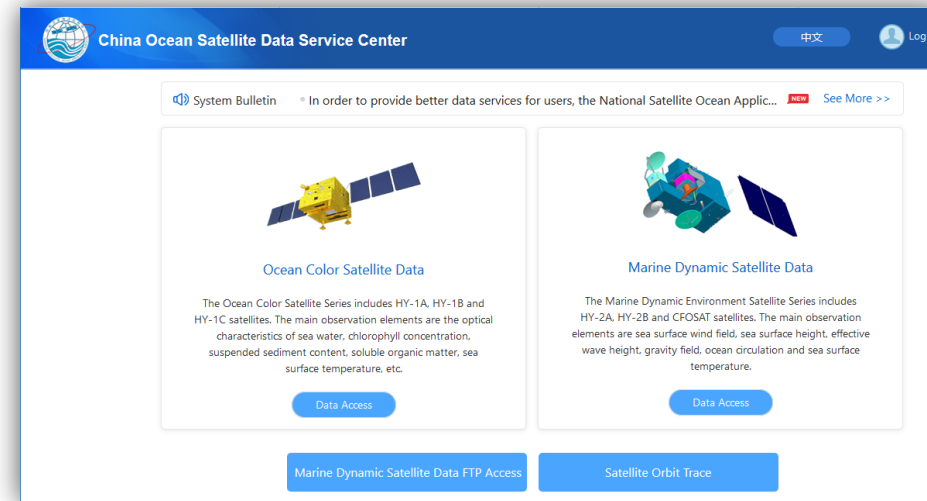


## System products from Mission Centers

- ❖ SWIM and SCAT level 1 and level 2 products
- ❖ On Aviso+ Website: <https://www.aviso.altimetry.fr/>
- ❖ On NSOAS Website: <https://osdds.nsoas.org.cn/#/>

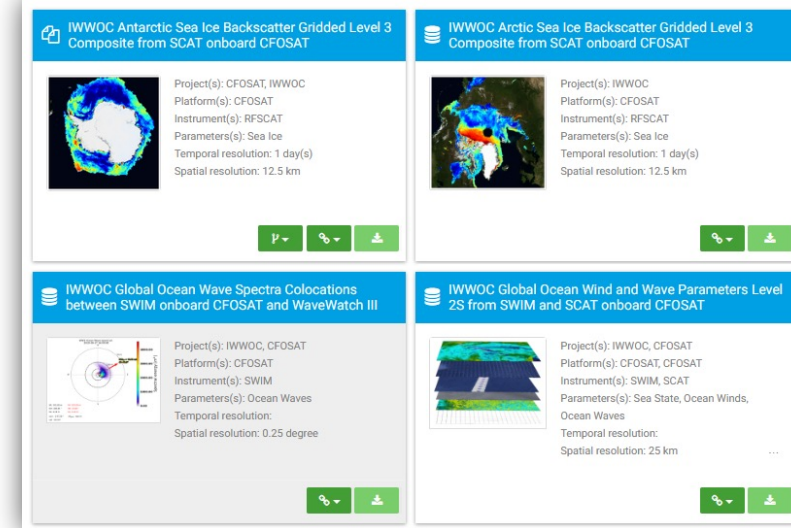
## Value-added products from CNES Mission Center (CWWIC)

- ❖ NRT products
  - SWIM-L2P-SWH-Nadir-1Hz
  - SWIM-L2P-OFF-NADIR
  - For Copernicus Marine Service operational usage
- ❖ NTC products
  - SWIM-L2P-SWH-Nadir-1Hz and 5Hz
  - Reprocessed series for climate studies
- ❖ Available on Aviso+ Website: <https://www.aviso.altimetry.fr/>



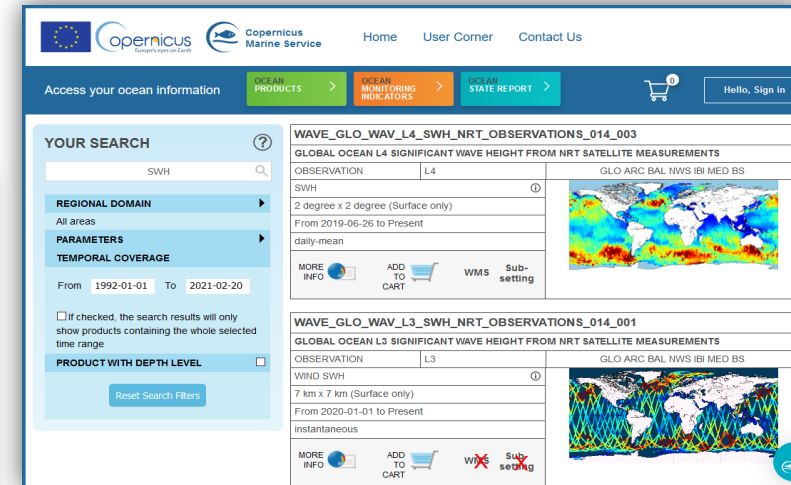
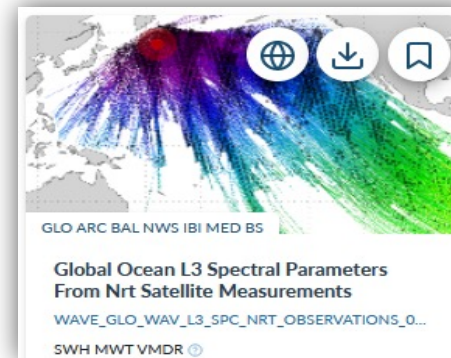
## Value-added products from Ifremer Processing Center (IWWOC)

- ❖ Higher level products : L2S to L3/L4 (global fields of wind and wave parameters)
- ❖ Synergy between SWIM and SCAT, alternative processing method and testing
- ❖ Cross-overs with altimeters/scatterometers/SAR and models (WW3)
- ❖ Match-ups with in situ data
- ❖ On ODATIS Website : <https://www.odatis-ocean.fr/>
  - Some products available since beginning 2022: SWIM-L2S, SCAT-L3-ICE, Colocations SWIM-WW3
  - Others products to come soon...



## Products from Copernicus Marine Service

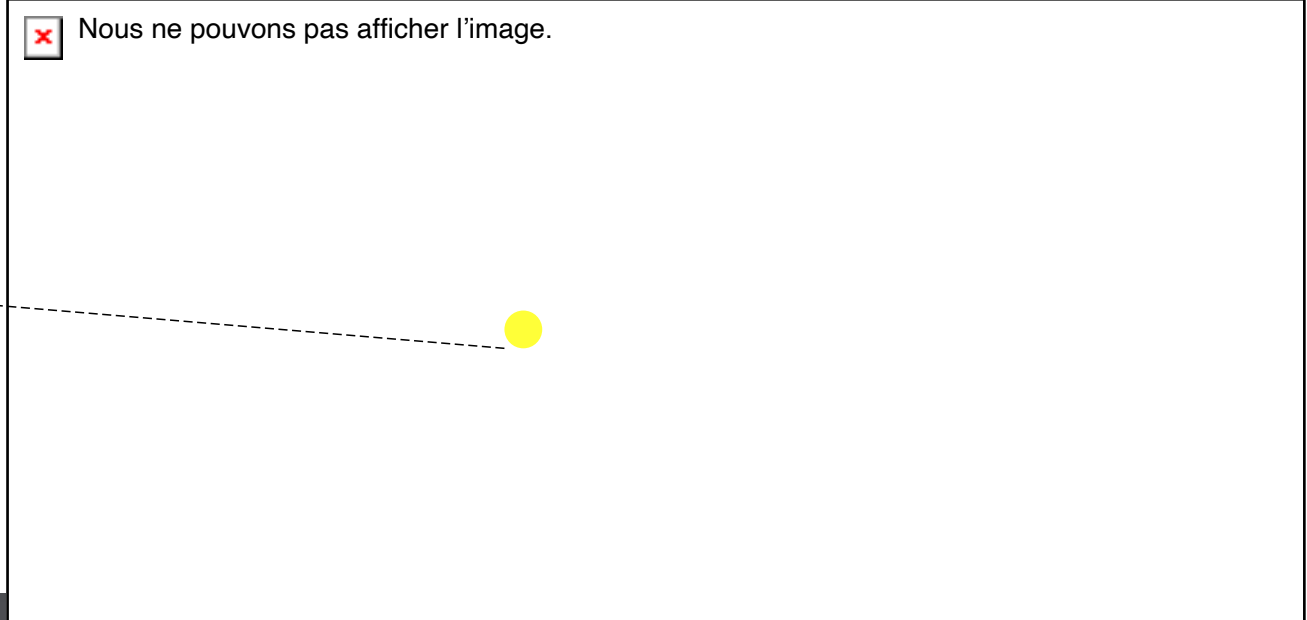
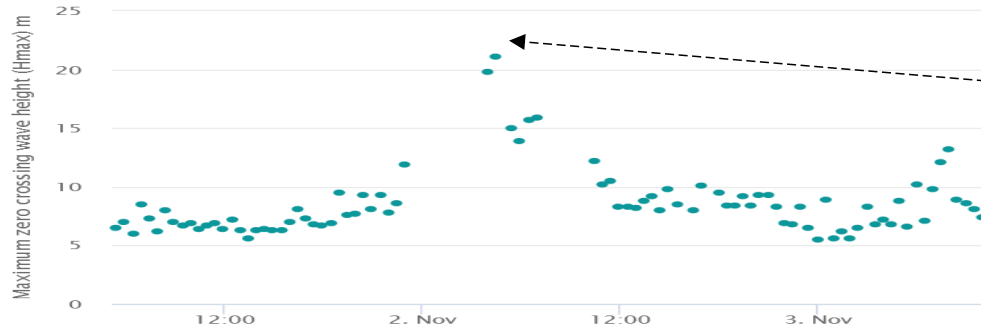
- ❖ Global L3 and L4 SWH NRT products
- ❖ L3 Spectral NRT products
  - CMEMS website: <https://resources.marine.copernicus.eu/>



# Satellite image during Ciaran huge Storm (2 November 2023)

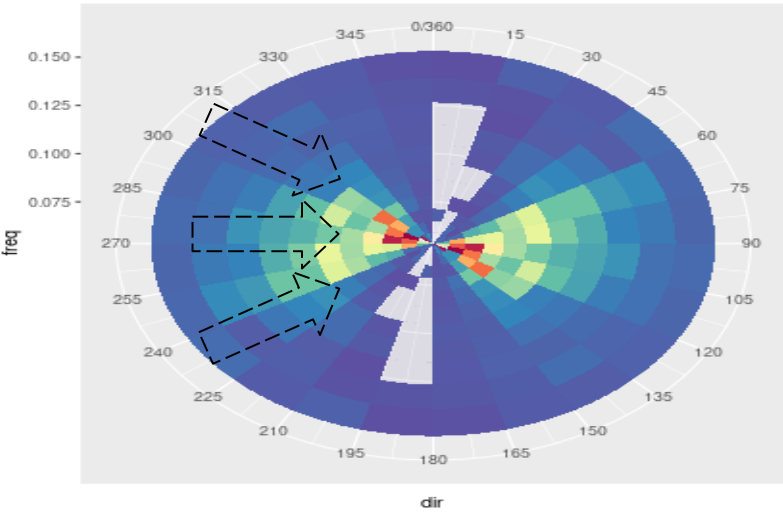
cnes

**High waves generated by the storm at the coast  
Maximum wave height of more than 21.3 meters  
recorded at buoy Pierre Noires (Finistère)**

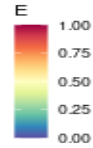


## Complex waves systems

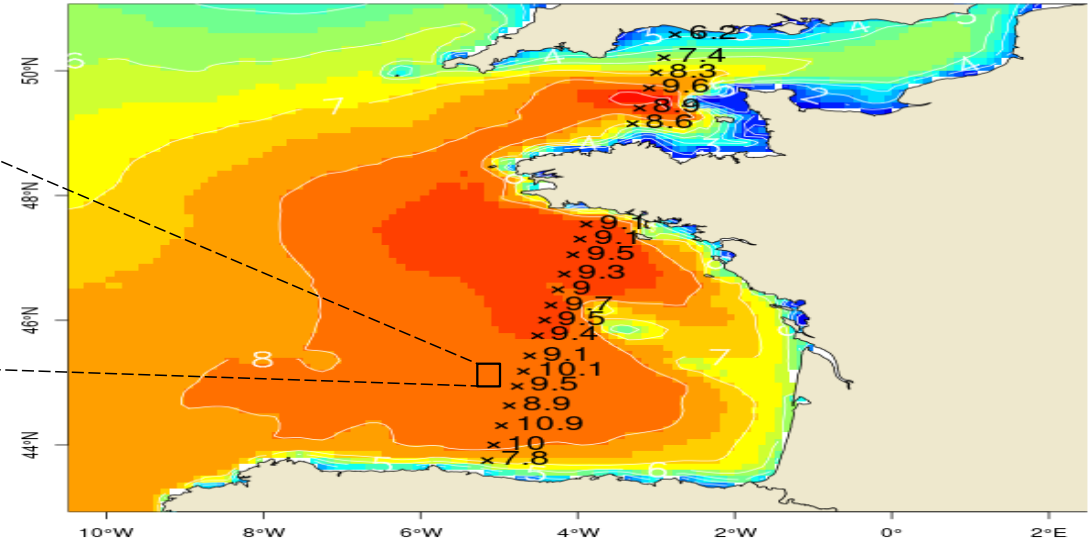
Max = 62.84m<sup>2</sup>/Hz | SWH = 9.6 m



## SWIM directional wave Spectrum in the storm

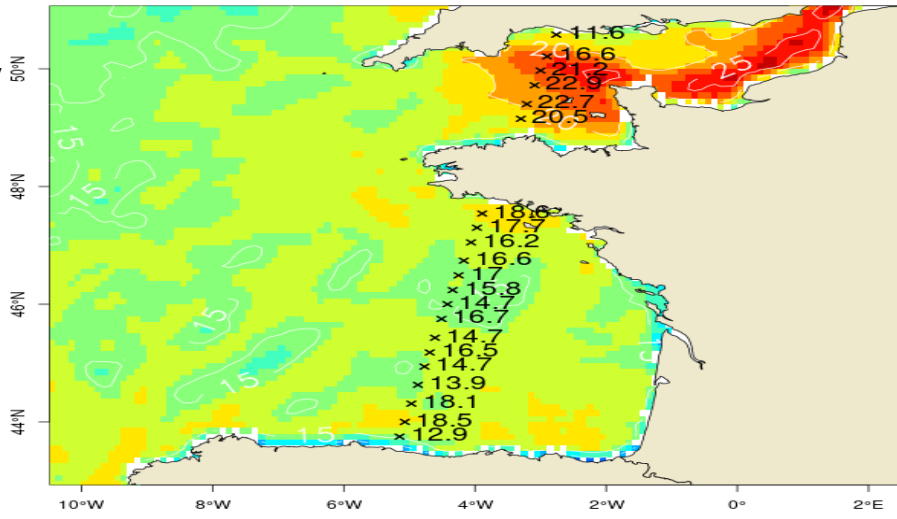
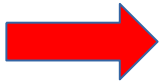


## Along track SWH from SWIM nadir 2 November 2023 at 07:53UTC



Snapshot of SWH from MFWAM Forecast on 2 November 2023 at 06:00  
Good

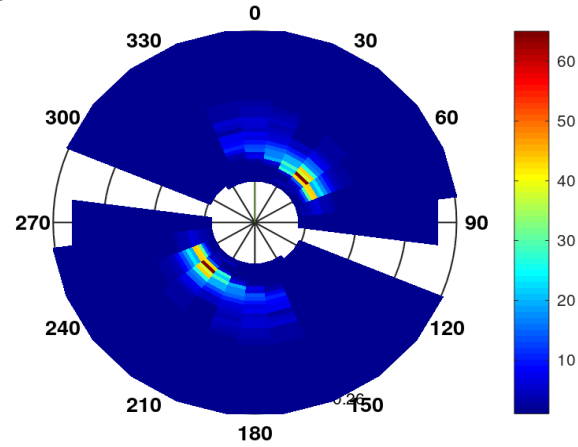
Good consistency of SWIM nadir wind speed and ECMWF



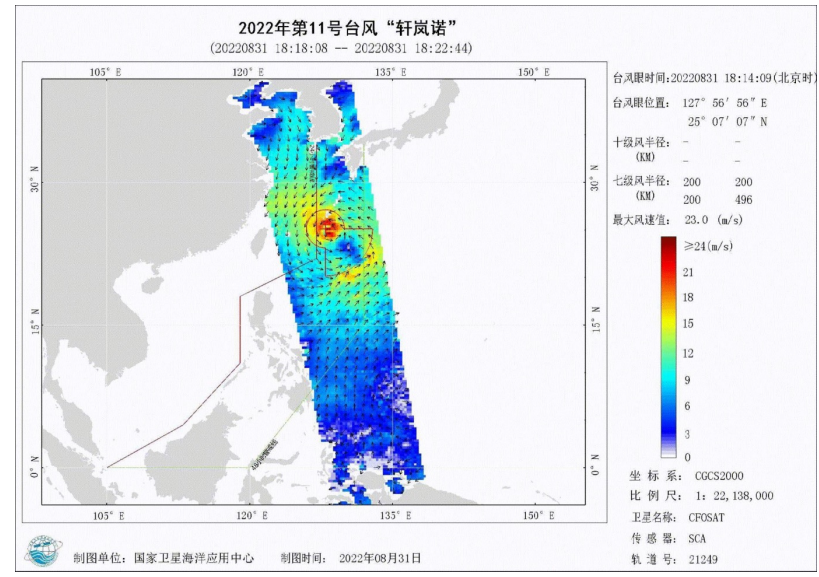
# Science: uniqueness of CFOSAT

- ❖ Transition from short wind-waves to long wave (growth, extreme,...)
- ❖ Wind variability in critical seas
- ❖ Better sampling of SWH
- ❖ Wide swath SWH
- ❖ Sea ice...and further more

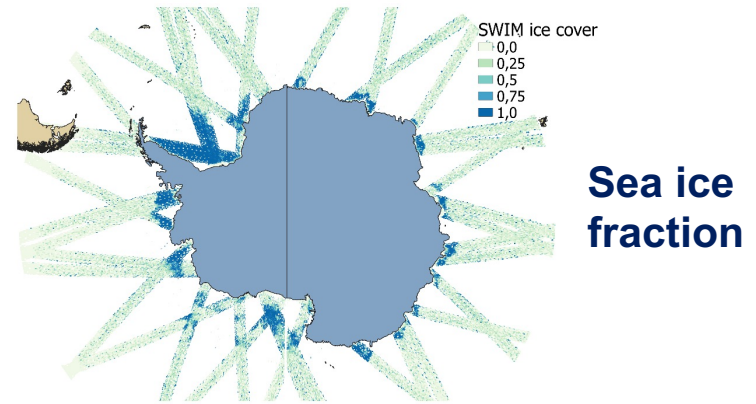
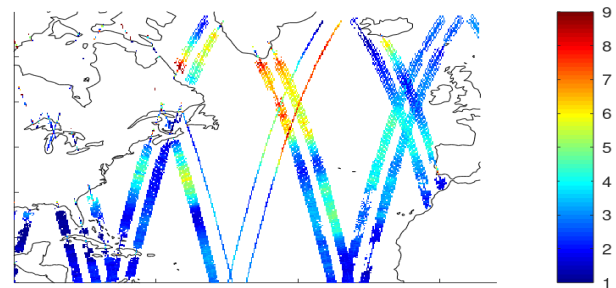
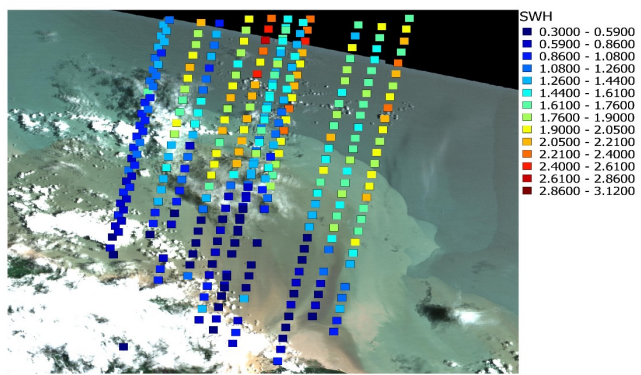
## SWIM spectrum



## SCAT wind field

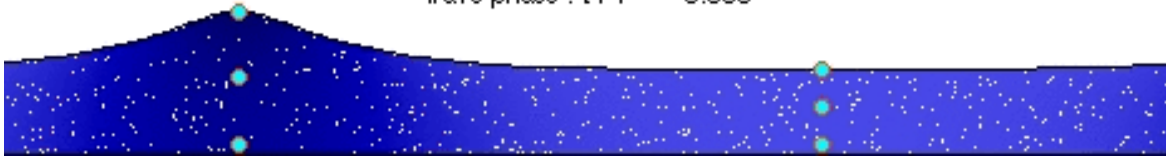


## SWH nadir 5Hz



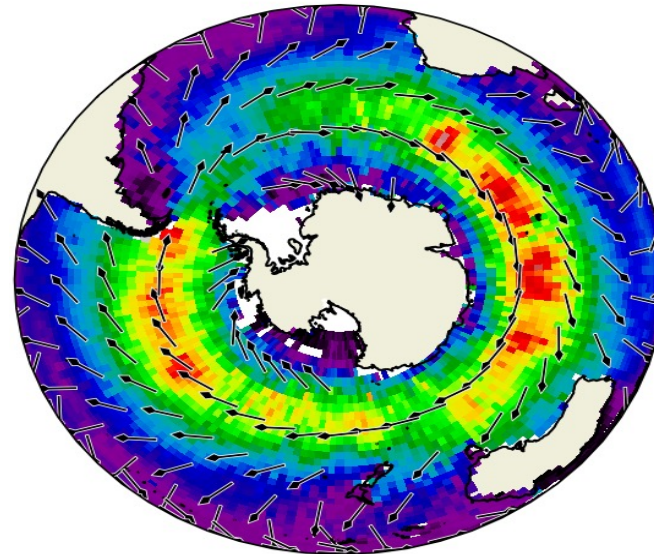
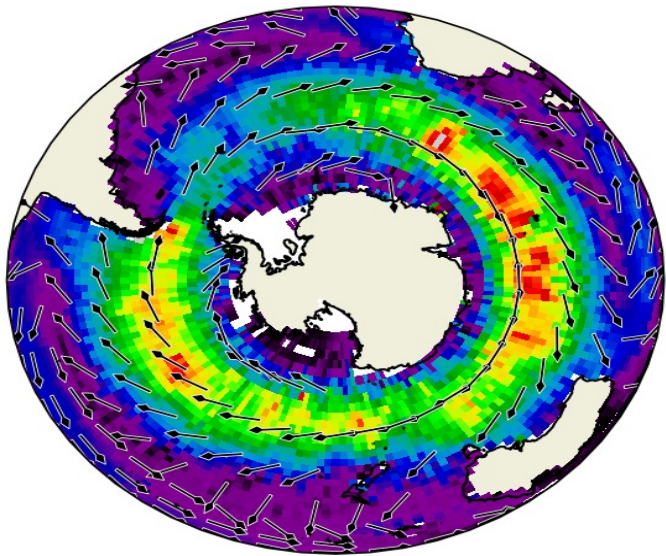
## Stokes drift estimated from the SWIM wave spectra

wave phase :  $t/T = 0.000$



SWIM (beam  $10^\circ$ )

MODEL  
(MF-WAM) depth= 15m



Stokes drift from SWIM, estimated over wavelengths larger than 30 m)  
=> representative of Stokes drift at 15 m depth

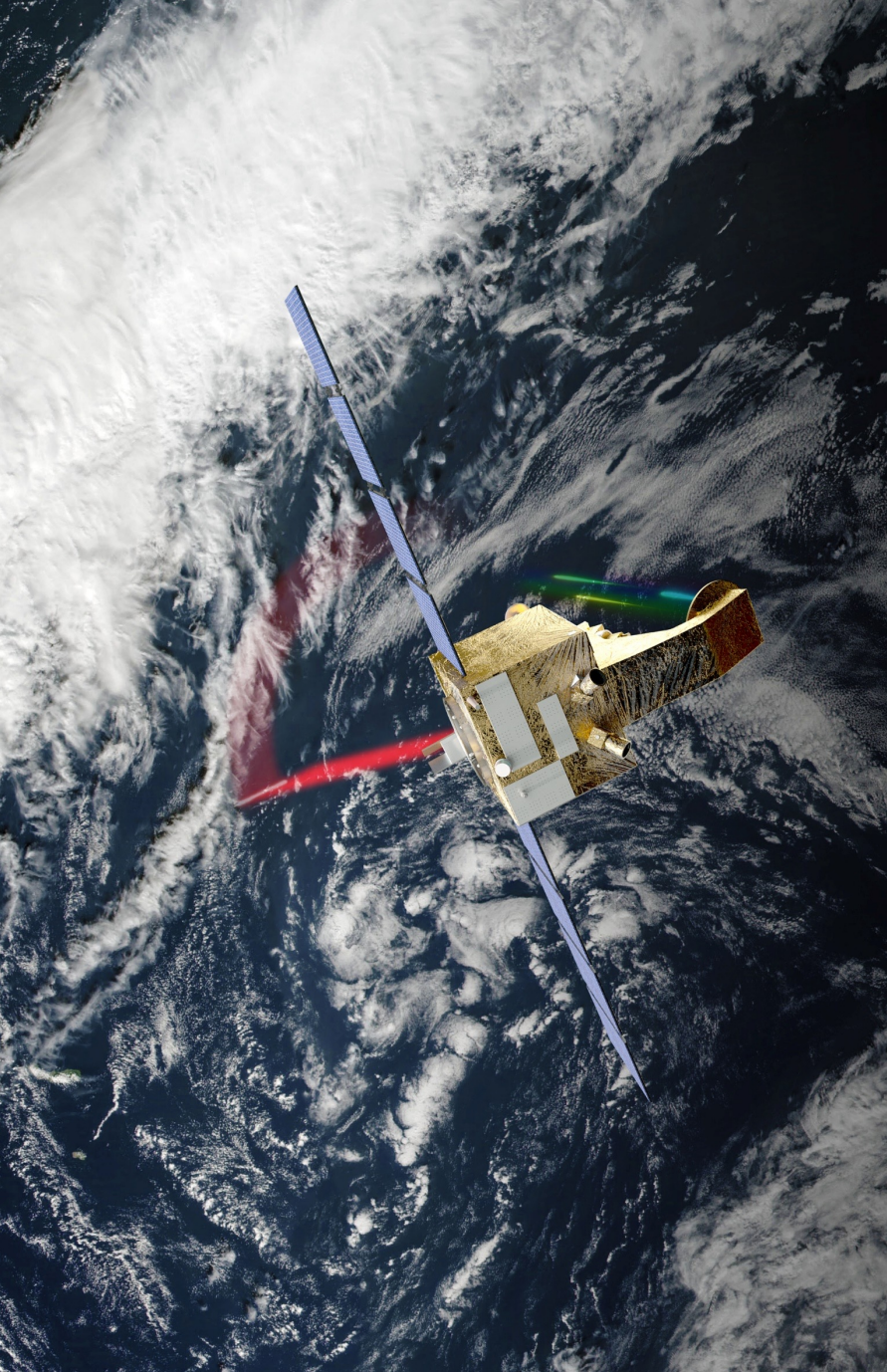
By extrapolating the wave spectrum for waves shorter than 30m, surface Stokes drift can also be estimated



## Several achievements related to mission exploitation and outcomes from the Science Team

- ❖ Validation and improvements of processing and products (SWIM & SCAT)
- ❖ Geophysical analysis: global wave field properties, specific cases analysis - tropical cyclones, wave-current interactions, coastal, ocean/atmosphere interactions, indicators for extreme waves
- ❖ Operational use of CFOSAT directional wave observations in wave forecast (CMEMS, MF,...) and preparing a better coupled models (ocean/waves/atmosphere)
- ❖ Implementation and retrieval of new products from CFOSAT: Stokes drift (oil spills and drifting bodies), sea ice fraction and classification, orbital velocity, estimate of Mean Square Slope,...
- ❖ Complementary use with other missions: better capturing of small scale of waves than Sentinel-1

Learn more at CFOSAT Poster Session



**CFOSAT Mission continues to perform well after five years in orbit for SWIM instrument**

**It's a great success**

**To be continued and exploring more scientific applications...**

### **To come:**

- ❖ Extension of SWIM-NRT products distribution through WMO/GTS
  - In coming weeks
- ❖ SWIM: OP07 product version next year
- ❖ SCAT: new processing wrt stop antenna rotation

A detailed 3D rendering of the CFOSAT satellite in space. The satellite features a central white and grey body with gold thermal blankets, a large circular dish antenna, and a long array of solar panels. The Earth's horizon is visible at the bottom, and the background is a starry space.

CFOSAT

谢谢！ Thank you！ Merci！